Forestry Research West

Forest Service
U.S. Department of Agriculture

November 1979

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A report for land managers on recent developments in forestry research at the four western Experiment Stations of the Forest Service, U.S. Department of Agriculture

In This Issue

Cover

Scientists at the Pacific Southwest Station are studying the "voiceprinting" of forest birds such as this spotted owl. This identification process could greatly reduce the need for capturing and banding. Read about it on the facing page. (Photo courtesy of Gregory Shearer).

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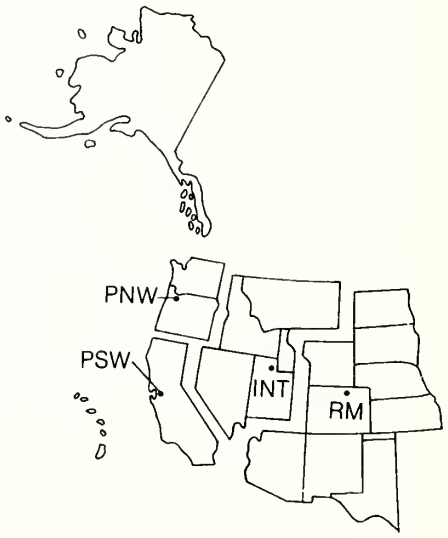


Scientists "voiceprint" forest birds

by Marcia Wood
Pacific Southwest Station

Logging can result in a loss of habitat for the spotted owl. (Photo courtesy of Gregory Shearer)

"Voiceprinting" the calls of forest birds may be a reliable way to distinguish one individual from another, according to Research Wildlife Biologist Jerry Verner of Fresno, California. Verner, who is in charge of the Pacific Southwest Station's research on sensitive, threatened, and endangered wildlife and plants in California, has arranged for the voiceprinting technique to be tested in Station-sponsored studies of the Southern bald eagle, American peregrine falcon, and spotted owl. The eagle and falcon are endangered species; the spotted owl population is regarded as sensitive.

"Voiceprinting has been used successfully in studies of other birds, such as the prairie falcon," Verner says. "A voiceprint can be as accurate in identifying a bird as a fingerprint is for identifying a person. If voiceprinting works in our studies, it could greatly reduce our need to capture and band birds. This would be an especially important advantage in our studies of rare, threatened, and endangered birds, in that it would eliminate the stress of capture."

By comparing voiceprints taken at one time of the year with those taken at later intervals, Verner and his colleagues hope to learn about the movements, habitat needs, and life span of the eagle, falcon, and owl. This information would be shared with forest managers, to help them make sure that their plans for logging, grazing, and similar activities, do not interfere with wildlife needs.

Voiceprints are made by recording the calls of each bird with a high-fidelity tape recorder. The tapes are then fed into an audiospectrograph, which produces a printout, known as a voiceprint or sonagram. Verner explains that the voiceprint is "a picture of the sound—a tracing, made on special paper, that gives information on the duration, pitch, and volume of notes in the calls." He says that voiceprints are easy to read, "once you develop a knack for it. When you spread out a collection of voiceprints in front of you, and start comparing them, it's fairly easy to see differences among individual birds." By revisiting the sites at which the recordings were first made, and by comparing the later recordings with the original tapes, Verner and his associates will be able to determine if the same birds are still occupying the same territory. Professor Luis Baptista and graduate student Robert B. Johnson of Occidental College, Los Angeles, are doing the spotted owl studies. They say that owls are extremely sedentary, a factor which should make it easier for the researchers to relocate individual birds later in the study. They hope to record at least 30 owls.

Bob Lehman of the Wilderness Research Institute, Arcata, California, has visited nest sites of the peregrine falcon and Southern bald eagle, to make recordings of these birds. He explains, "There are approximately 40 nesting pairs of bald eagles in California. Each year, they use some of the 58 nesting territories in the State." He wants to learn more about this pattern of use. Which nests remain unused from year to year? Which nesting pairs rotate their choice of nest? Do the eagles follow a predictable pattern in moving from one nest site to another?

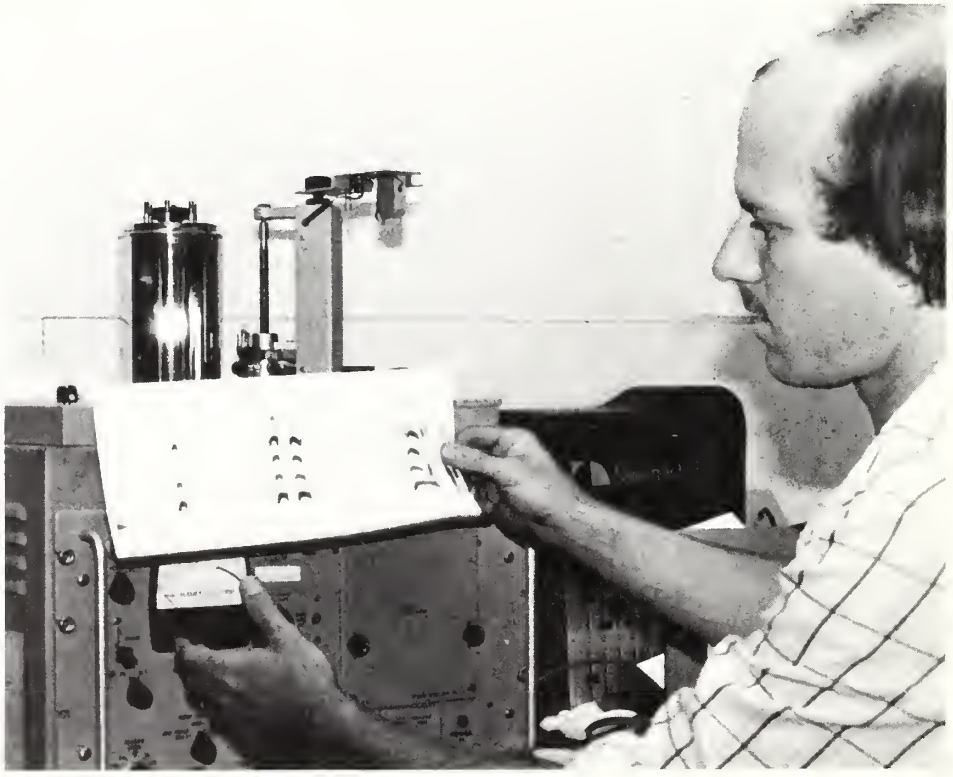
The cowbird

Another major study that Verner is coordinating is on the brown-headed cowbird, and the potential threat this bird poses to native songbirds in the Sierra Nevada. This first in this series of studies showed that cowbirds have invaded the Sierra Nevada over the past 40 to 50 years, in the same way that they spread East and West, from the Great Plains, more than 100 years ago. "Some researchers believe that the cowbird has played a major role in the decline of the near-extinct Kirtland's warbler," Verner says. "Our Sierra Nevada study shows that cowbirds may already be threatening the warbling vireo. We suspect that the solitary vireo and the yellow warbler may be similarly threatened."

The cowbird threat to these songbirds stems from the fact that cowbirds are "nest parasites"—they deposit their eggs in the nests of host species, and leave the host birds to raise the cowbird young. "The cowbird has one of the shortest incubation periods of any American bird," Verner explains, "so the cowbird young will usually hatch sooner than the eggs of the host. This gives the cowbird an almost unbeatable head start. When the host young hatch, the cowbird still is at an advantage—the parents will normally feed the largest and most active of the young first, and this, of course, is the cowbird. The other young may weaken and die, while the cowbird thrives, leaves the nest, and starts the cycle all over again."

Verner is especially concerned because the cowbird is a "generalist"—it will use the nests of almost any species, except those of particularly aggressive birds or those of species that nest in holes. This means that if an individual species of songbird starts to decline, because of cowbird pressure, the cowbird can merely shift its attention to any one of a number of other host species.

Dr. Stephen I. Rothstein of the University of California at Santa Barbara, an international authority on cowbirds, is conducting the Sierra Nevada studies. This past summer's work has focused on feeding patterns. Rothstein and his assistants captured, banded, and outfitted several birds with radio transmitters, to see if the birds flocked at mid-day to feed at sites used by people and domestic animals. The study is expected to provide recommendations about how to prevent further buildup of cowbird populations in the mountains.



Robert Johnson of Occidental College is analyzing voiceprints of spotted owls. (Photo courtesy of Gregory Shearer)

A new study will show how grazing affects the composition of bird communities in pine-oak woodlands.

The voiceprinting study and cowbird investigations are just a few of almost a dozen different studies that Verner's research group is either conducting or coordinating. This list of projects includes, for example, studies of the effects logging may have on resident and migratory forest birds. Terry A. Larson, a Ph. D. candidate at Illinois State University, is sampling birds on some 52 different mixed-conifer sites that have already been logged. Verner will be inventorying bird communities in other mixed-conifer and red fir forests, both before and after logging.

Another study concerns grazing and its effects on the birds in digger pine-blue oak woodlands of central California. The study results should be applicable to pine-oak woodlands throughout the foothills of the west-side Sierra Nevada. As with the other work, one of the primary goals is to give foresters and range management specialists detailed information about bird use of this ecosystem. Verner, along with his assistant, Lyman Ritter, and graduate student Sallie Caldwell of the University of California at Davis, are working on this study.

Field reference

Forest Service policy and a series of Federal laws require that public land management activities be directed towards maintaining an abundance and diversity of wildlife species—something the wildlife biologists term "species richness." Verner has been instrumental in producing a new publication that should help meet these objectives. The report is a series of reference charts that indicate the vegetation type an individual bird, mammal, reptile, or amphibian uses at different times of the year, and for what purpose—breeding, feeding, resting, or other activity. Twelve different plant communities are indexed in these "wildlife/habitat relationship" matrices. The report, which will be issued by the Pacific Southwest Station, covers 355 species of wildlife. In addition to the matrices, it also has further information on each species, and maps showing distribution. Verner says the report will be the first of its kind for California wildlife, and that it will be an invaluable field reference for people who prepare environmental impact statements of management plans for Western Sierra wildlands. The species data have already been entered into a computer system, and can be retrieved for analysis of proposed management activities.

For example, a forest manager could run a computer analysis to determine which species may increase, following logging, and which may decrease. These analyses are available through the National Forest System's Pacific Southwest Region. The Region had overall responsibility for producing the habitat matrix report.

The Unit has also worked closely with the Pacific Southwest Region on another major project—this one concerning the mule deer in the North Kings Herd. The Forest Service and several other agencies are cooperating in an intensive, 10-year program, which is designed to increase this Sierra Nevada herd and to provide the best possible habitat for the animals. "The primary problem with the herd is that many of the fawns don't live to maturity," says research range scientist Donald L. Neal. Neal, technician George Steger, and several assistants, have outfitted some of the fawns with radio transmitters, and have monitored their movements—from as far a distance as possible—at regular intervals. They've noted how far the animals range, and what types of surroundings they prefer. "So far, we have found that their home ranges are much larger than we expected," he reports. "Early in summer, they use about an acre to an acre-and-one-half. By the end of the summer, they are covering about 240 acres a day. It also came as a surprise to us that they seem to like fir thickets, sometimes choosing to stay in these rather than a meadow or brushfield." One of Neal's current projects is to find out if fawns or their mothers retreat to less desirable portions of their range when cattle move in to graze. "We need to know more about competition between deer and cattle, ' Neal says, "especially the competition between cattle, does, and fawns."

Forestry Research readers who would like more information about these and other studies are invited to write to the Sensitive Species Protection and Management Research Unit for further details. Their address is: Pacific Southwest Station, Forestry Sciences Laboratory, 2081 East Sierra Avenue, Fresno, California 93710.

Deer in the North Kings Herd range over some 792 square miles of the Sierra Nevada.

The Progressive Tree Improvement Program

by Dorothy Bergstrom
Pacific Northwest Station

A plan for forest tree improvement has grown rapidly in the Pacific Northwest because it was specifically designed to meet local needs. Proposed in 1966 as a simple, genetically sound method to help a timber company get improved Douglas-fir seed for reforestation, the plan has since been adapted to meet the needs of other timberland owners and has become known as the Progressive Tree Improvement Program. Today, under this Program, 33 cooperating landowners are engaged in tree improvement on 18 million acres of public and private forest land in Oregon and Washington

The Progressive Tree Improvement Program builds on the genetic improvement that has occurred naturally over the past million years or so to give the Douglas-fir region a heritage of highly productive forests. These forests cover a surprisingly wide variety of ecological sites, and the trees have evolved genetic adaptations to those sites. The program respects and protects the natural system while at the same time pushing natural selection to produce modest increases in growth and improvement in economically important traits such as form, straightness, and resistance to insects and disease.

The improvement results when seedlings are planted from seed of precisely adapted local parent trees with proven ability to pass on desired characteristics. The test of a parent tree's ability to do this is the performance of a group, or family, of each tree's progeny over a 20-year period. Incremental gains in volume growth for the Progressive Tree Improvement Program accumulate to about 10 percent in the first 20 years.

A plantation of genetically improved Christmas trees.

Sometimes tree breeding involves climbing very tall trees. (Bureau of Land Management photo)

The original approach to tree improvement in the Douglas-fir region had been to establish grafted seed orchards. These consisted of seedlings planted in rows like fruit trees, which had been grafted with twigs from superior looking, mature forest trees. The mature grafts were expected to pollinate each other and bear seed which would be convenient to gather from the sapling-sized trees concentrated in a small area. The method had worked well for other tree species in other regions of the United States. But by 1966, the 16 grafted Douglas-fir seed orchards then established in the Pacific Northwest had begun to fail. There were serious problems of graft rejection, pollen contamination, slow and cyclic cone production, heavy capital expense, and the need for specially trained personnel.

In 1966, Crown Zellerbach Corporation came to geneticist Roy Silen of the Pacific Northwest Station seeking help. The company wanted to improve its source of Douglas-fir seed but get rid of the problems associated with grafted seed orchards. The plan Silen proposed was flexible, low in cost, and the techniques could be easily learned by field foresters. The plan was also conservative because it utilized the genetic heritage of a large number of locally adapted trees. Speaking about the program more than a decade later, Silen says, "It was a way to capitalize on the natural goodness already in the gene pool. There may be 8 or 10 economically important traits we can gradually improve somewhat, but there are probably hundreds more that fit our trees to their environments and should be deliberately kept as they are."

The original plan for Crown Zellerbach was soon being adapted to fit the needs of other landowners in the Douglas-fir region. Silen recommended that neighboring landowners join together to share the expenses and benefits of a program adapted to their particular needs and the ecological sites of their land. They agreed, and cooperatives—usually made up of owners of an entire watershed—sprang up as the organizational basis for improvement programs. The Industrial Forestry Association, an organization of private forest landowners, adopted Silen's basic plan as its primary program and began developing nursery facilities to raise seedlings for testing. Joe Wheat, geneticist for the Association, joined Silen in providing leadership and advice to the cooperatives. Following the adoption of an improvement plan, each cooperative administered its program with guidance from Silen and Wheat on scientific and technical problems.

The basic program for Douglas-fir, from which specific programs for individual cooperatives vary somewhat, has three breeding phases spanning an anticipated 40 to 50 years. It works like this:

Breeding Phase I

The cooperators' first step is to select and label parent trees on their lands. Most programs are based on 300 well-distributed parent trees or about 3 trees per 1,000 acres. Each tree must be capable of bearing a bushel of cones. Trees are usually located near roads for good accessibility and are easy to climb. They are usually superior in size, form, or other visible characteristics. However, it is proof of their ability to produce offspring that survive and grow well and have other desired characteristics that is important and is to be determined from tests in Phase I.

During a good seed year, at least a quarter bushel of cones is collected from each parent tree. Since the seed has been pollinated by wind-blown pollen, only one parent is known. Silen says this is not a problem. "The pollen has come from multiple trees growing nearby. Thus, the progeny are adapted to the breeding site and usually provide a good average mixture of inheritance of the local population," he says.

Male catkins of Douglas-fir prior to pollen release. (Bureau of Land Management photo)

A second generation seed orchard composed of progeny from crosses of parent trees in the Willamette River Valley of Oregon.

Enough seed to produce 100 to 150 test seedlings from each parent is planted in a nursery. After growing for a season, the seedlings are planted on 6 to 12 test sites provided by members of the cooperative. The test sites are from 5 to 15 acres in size, are ecologically uniform, and represent the environments where seedlings will replace harvested trees. The seedlings are planted in families of 12-24 seedlings from each parent tree. The testing sites include an elevation range of about a thousand feet to sample the response of seedlings to elevation. At regular intervals, usually every five years, the seedlings are measured for survival, height and diameter growth, taper, form, straightness, and resistance to insects and disease. On the basis of this information, the parent trees are then ranked in order of desirability as sources of seed for commercial planting.

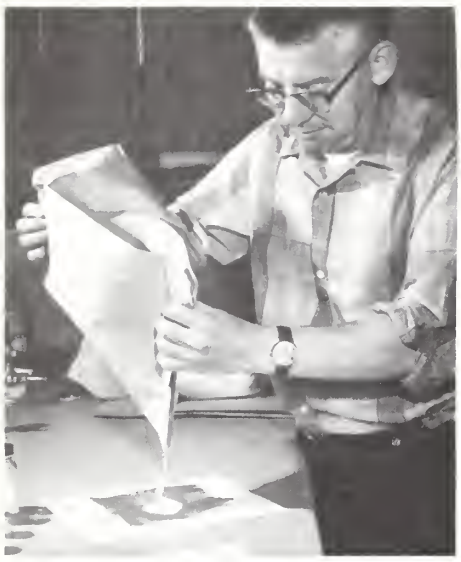
Commercial-size collections of seed from the parent trees are used for reforestation during the first 15 to 20 years of the program. As the performance of the progeny indicates which parents are the best producers, seed is gathered from a gradually reduced number of the best parents. This incremental improvement of seed following each measurement is the basis for the name—Progressive Tree Improvement Program.

Breeding Phase II

In the second phase of the program a second generation seed orchard is established. It is composed of seedlings—not grafts from superior trees as in the grafted seed orchards. It is usually planted within the first five years of the program so that by the time the best parent trees are identified from Phase I, trees in the seed orchard will be 15 to 20 years old and ready to bear seed.

Phase II begins with random mating of all parent trees (300 parents produce 150 crosses). Technicians climb the parent trees, collecting pollen from the male catkins of half the parent trees and placing pollen-proof bags over the female cone flowers on the remaining trees to protect them from natural pollination. Later, the female coneflowers are supplied with pollen from the male catkins. Paper bags protect the fertilized cones until fall when the seeds are developed. Because the pollen has been applied directly instead of drifting on the wind, the cones contain seed with both parents known.

When the seedlings from these crosses have grown in a nursery for one or two years, they are planted to begin the second generation orchard. Not all of them will live to become seed producers. As measurements from Phase I change the rankings of parent trees, the seedlings in the seed orchard are also ranked. Seedlings of the lower ranking parents are gradually "rogued," or discarded. After 15 or 20 years, only individuals of the best third of the families are left. These remaining trees will pollinate each other and produce seed for commercial planting for the next 15 years—replacing the parent trees as seed sources. As of 1979, four of the cooperatives had established second generation seed orchards.



Geneticist Bob Campbell of the Pacific Northwest Station prepares seed for laboratory studies.

Breeding Phase III

A third breeding phase is planned but will not begin until about 1989 for the first cooperative established. In this third phase crosses will be made of the best individual trees from the best families to establish a third generation seed orchard.

Advantage of the Program

Silen says there are several reasons the program has become popular. Cost is clearly one advantage. "It was proposed at time when serious problems with grafted seed orchards were discouraging investment in tree improvement, and forest landowners were interested in assured gains from a modest investment," he says. The program can be used by owners with few resources; it offers a way to obtain improved seed without expensive investment in grafted seed orchards. In addition, the technology can be easily learned by field foresters. And advice and help with scientific and technical problems is available from the Experiment Station and the Industrial Forestry Association.

Flexibility is another advantage. Following adoption of the genetic design for improvement, each cooperative makes its own decisions on methods and scope. They decide, for example, how many parent trees to test, standards for selecting parent trees, traits to breed for, and how far to carry their breeding program, hence the type of their investment.

Still another advantage is the adaptability of the program to other tree species. Although the program was designed for Douglas-fir, its principles have since been incorporated in similar programs for western hemlock, noble fir, and ponderosa pine.

A firm scientific base

Silen based the initial plan for tree improvement on a similar program he had designed for Northwest Christmas tree growers in 1964. Both programs were based on findings from long-term genetic studies Silen has been closely associated with for many years. One is a study of Douglas-fir heredity which was started by Experiment Station scientists at Wind River, Washington, in 1912. The other study is at the Wind River Arboretum and also dates from 1912. Both studies have proved the presence of strong inherited adaptation to particular localities and indicated a potential for improving a wide range of traits through genetic selection.

"What we have here in the Pacific Northwest is so good," says Silen, "we should not threaten the genetic pool by trying to improve growth too much. If we become greedy, we could damage or lose a priceless genetic heritage that belongs to future generations."

Although the Progressive Tree Improvement Program is now a small part of Silen's work as a geneticist and research leader, he has discussed the program and the scientific basis for it in several recent publications. These include "Progressive Tree Improvement Program in Coastal Douglas-fir" by Roy R. Silen and Joseph G. Wheat, *Journal of Forestry*, February 1979; "Genetics of Douglas-fir" (Research Paper WO-35); and "The Care and Handling of the Forest Gene Pool" by Roy R. Silen with Ivan Doig, *Pacific Search* June 1976. Copies are available from the Pacific Northwest Station.

Geneticists Roy Silen and Boyd Wilson of the Washington Department of Natural Resources examine a Douglas-fir grown in a tree improvement program.

Regeneration in the Southwest - It can work!

by Rick Fletcher
Rocky Mountain Station

"The consensus used to be that forest regeneration was very difficult, if not downright impossible. However, we've found that, by following strict guidelines and with a little luck, it can be done." Research Forester Frank Ronco was talking about regeneration in the Southwest. He is a Rocky Mountain Station project leader at the Forestry Sciences Lab in Flagstaff, Arizona. His unit is searching for ways to successfully regenerate ponderosa pine forests in this arid part of the country.

Regeneration in the Southwest has been a problem for many years. In fact, the first forest experiment station in the U.S. was established at Fort Valley, Arizona, in 1908, to deal with this problem.

In the past, grazing was the dominant use of southwestern forests, timber production was secondary. Tree growth was considered too slow and market places were too far away. Today, however, the tables have turned because of the growing demand for timber and timber products; and forest managers are more resolute in finding ways to get around the "lion in the road."

So, why is regeneration so difficult in the Southwest? Many factors enter the picture, including erratic precipitation, less than optimum soil conditions, browsing by deer, cattle and other animals, and competing herbaceous vegetation.

Ronco lists three requirements for successful regeneration: (1) a well prepared site, (2) seedlings protected from animals and the elements, and (3) proper training and supervision of field personnel.

Leroy J. "Pat" Heidmann, research forester at the Flagstaff lab, says that scientists have been conducting studies on both artificial and natural regeneration. He explains that there are advantages to both, "On volcanic soils planting is the only reliable method of gaining successful regeneration. For sedimentary soils, both planting and natural regeneration can work. By planting you can keep a closer control on tree genetics. However, it is far more expensive than natural regeneration."

(left to right) Frank Ronco and Pat Heidmann, Rocky Mountain Station, along with Don Wood and George Cullum, Chevalon Ranger District, check an area where the site was prepared for natural regeneration, then fenced to keep out cattle. Success is obvious.

Site preparation

While regeneration efforts have been carried out in many areas of the Southwest, the Chevalon Ranger District, on the Apache-Sitgreaves National Forest in central Arizona, is a prime example of what can be accomplished. Through close cooperation with researchers at Flagstaff, district foresters have shown that regeneration is not only a possibility in the Southwest, but that it can be quite successful on a large scale.

In 1968, district personnel were concerned because they had over 17,000 acres of understocked ponderosa pine stands. Despite good seed crops in prior years, few seedlings had become established. With limited funds, they aimed their efforts toward natural regeneration.

Ronco explained, "There is a definite prescription to follow in preparing an area for natural regeneration. The first step is to determine if a good cone crop can be expected in the area. Then conduct a rodent census the summer prior to seedfall. If rodent populations are high, control measures need to be taken to protect seeds and seedlings. An effective poison treatment is two pounds of zinc phosphide per 100 pounds of grain."

Ronco explains further, "Then mark the timber in the area for a shelterwood harvest and log it. Be sure to leave about five 20-inch diameter seed producing trees per acre. These trees, as well as others left in the shelterwood cut, contribute seed and furnish shade for seedlings.

Disking helps eliminate grasses that compete for water, prepares a mineral soil seedbed, and creates furrows that catch water — all important contributors to successful natural regeneration.

"In the fall, before cones open, the area should be disked with a heavy-duty gang disk. This removes competing grasses and breaks the ground into a mineral soil seedbed that is essential for successful seed germination. Disking also creates furrows that catch water and concentrates it in the first three inches of soil where it is most needed by newly-germinated seedlings. Cattle are allowed to graze the area until late summer, then they are removed for a number of years to protect the young seedlings.

George Cullum, a member of the District's timber staff, says, "Over the past ten years, more than 11,000 acres of ponderosa pine have been successfully established on the Chevalon District using this method. For example, a 6,000-acre cut-over area now boasts 1,100 established seedlings per acre. Other areas are similarly stocked. The cost ran about $24.00 per acre and resulted in a savings of $150.00 per acre, compared to planting. Savings for the entire 11,000 acres exceeded $1.5 million."
Ronco continues, "If success with natural regeneration is expected, this prescription must be followed veraciously. And, even then, there are factors that can limit success, such as poor soil conditions, lack of shade, steep slopes, drought, etc."

Another proven method for regeneration is planting either bare-root stock or greenhouse-grown container seedlings. Planting affords the opportunity to select genetically superior trees and ultimately improve forest productivity. Though expensive, containerized seedlings may be planted to improve survival under more adverse conditions.

Heidmann says, "Planting programs must be carefully planned. As in preparing sites for natural regeneration, several criteria must be met to insure success. A half-hearted attempt will only lead to failure." These criteria include: a well prepared site on which competing vegetation has been killed with an herbicide or eliminated by disking; strong, healthy seedlings, excluding all cattle and discouraging browsing by deer until the trees are well established (which usually means a number of years); and planting only when the soil is moist.

Although many factors are involved in the failure of regeneration in the Southwest, the most important is lack of precipitation during critical periods of the year.

Scientists at Flagstaff have tried various site preparation methods to help conserve soil moisture for planted seedlings. One involves the use of herbicides to control competing vegetation, especially perennial bunch grasses that rob soil moisture from seedlings. They found that when grassy areas intended for planting were sprayed first with Dalapon, a registered herbicide, grasses were effectively controlled and soil moisture was significantly increased. A second method involves scalping or mechanically ripping up and removing grasses.

The most significant finding is the apparent superiority of the herbicide treatment over mechanical removal, especially for the 0 to 8-inch soil depth. Moisture content in this soil layer is critical to regeneration success. Planted seedlings usually have roots 8 to 10 inches long, but the roots do not grow for a month or more after planting, drawing heavily on nearby available moisture as they adjust to their new surroundings.

Sprayed plots held 11 percent more moisture than scalped plots in mid-August, and 14 percent more by mid-September. Heidmann believes the primary reason for the difference is that the mat of dead grass serves as a mulch to reduce evaporation, and it may also help to deter runoff and erosion.

Protecting regeneration

Scientists have also been working on ways to minimize frost heaving - a process of soil freezing and thawing that lifts the seedling upward, exposing the roots and resulting in mortality. In the laboratory they have studied three control methods: (1) preventing water in the soil from freezing by adding chemicals such as calcium chloride or calcium sulfate to the soil; (2) plugging the soil pores, thus reducing the permeability of water by using dispersing agents such as sodium polyphosphates; and (3) cementing the soil particles together with a bond, such as ferric chloride, strong enough to resist the expansive forces of frost action.

Spraying can be an effective method for eliminating competing grasses prior to planting. The dead grass provides a moisture-conserving mulch.

Frank Ronco, left, and Don Wood of the Chevalon Ranger District, look for new seedlings in an area that has been disked in preparation for natural regeneration.

In 1967, this area was planted to ponderosa pine following a large wildfire. George Cullum of the Chevalon Ranger District explains that little site preparation was necessary as planting occurred soon after the fire and before competing grasses became established.

In the laboratory, ferric and calcium chloride were quite successful. A more significant finding, however, with potential for wide-spread application in the field, was that frost heaving is directly related to soil bulk density. Frost heaving tends to increase as the bulk density for a particular soil increases. Heidmann believes that thoroughly loosening the soil by disking can effectively lower bulk density and reduce natural seedling losses to heaving.

Deer can effectively retard regeneration of ponderosa pine in the Southwest by eating the tender new growth. Young trees may be killed or kept in a hedge-like stage indefinitely. However, since trees browsed for many years usually have extensive, well-established root systems, they can grow out of reach of deer rapidly if protected.

An animal damage study, conducted on the Fort Valley Experimental Forest near Flagstaff, revealed that TMTD (tetramethylthiramdisulfide) applied to the branch tips of hedged ponderosa pines, effectively protected them from browing for one growing season. Subsequently, hedged seedlings on 240 acres of the Experimental Forest were sprayed annually with TMTD. After three years, most had outgrown the reach of deer.

As the national need for timber and timber products grows, the contribution made by Southwestern forests will become increasingly important. Successful regeneration will help make this contribution a reality. George Cullum summed it up saying, "There are currently about 120,000 acres intended for reforestation in New Mexico and Arizona. We now know the steps we need to follow and, with a little luck, we can reestablish thriving forests on most of these areas."

If you would like additional information on regeneration of ponderosa pine forests in the Southwest, contact Frank Ronco at the Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Northern Arizona University, Flagstaff, Arizona 86001. Phone (602) 774-5261, Ext. 1521, FTS - 261-1521.

Publications

Tussock moths get low-level air lift

Do outbreaks of the Douglas-fir tussock moth spread over long distances because the tiny larvae are air-lifted by the wind? Probably not, says insect ecologist Russ Mitchell of the Pacific Northwest Station, thereby answering a long-standing question in forest entomology. Mitchell drew his conclusions from a study of two insect-free areas surrounded by extensive infestations in Oregon and British Columbia.

Some larvae do travel by air. They spin long silk threads and drift in the wind. But most don't travel very far. Data suggest that even larvae with very long silk threads don't have the buoyancy to travel more than 1,500 feet. The distance most travel is closer to 600 feet. Mitchell concluded that dispersal from heavy populations is not likely to create new outbreaks much more than a quarter of a mile away and that dispersal from more normal densities poses no threat of new outbreaks.

The studies also revealed additional information. About 96 percent of the dispersal occurs in the first instar when the larvae are tiny, light, and covered with very long hairs. Mitchell found the heaviest concentrations of larvae on the downwind side of insect-free areas. Airborne dispersal occurred only in daylight. On sunny days it started at first light and stopped at sundown. On cloudy days dispersal began when temperatures reached 50°F. Most dispersal occurred when winds were gentle. There was no dispersal in heavy winds and no significant dispersal in rain.

Details of the study are reported in "Dispersal of early instars of the Douglas-fir tussock moth" by R. G. Mitchell, which appeared in the *Annals of the Entomological Society of America*, March 1979. Reprints are available from the Pacific Northwest Station.

New aids for logging engineers

Forest engineers at the Pacific Northwest Station have previously developed several applications for the use of programmable desk-top calculators in designing timber harvest areas and logging roads. Now they have come up with two new programs that will help engineers meet environmental and visual standards for timber harvesting.

The programs calculate average yarding distances and area size for irregularly shaped harvesting units which have complex boundaries and may contain streamside and visual buffer zones. One program is for cable systems which do not have lateral yarding capability; the other is for skyline systems with lateral yarding capability in either parallel or fan-shaped settings. The programs are written in the American Standard Code for Information Interchanges (ASCII) Basic language which is common to many present-day interactive computer systems. They are described in *Determining average yarding distance,* by Roger H. Twito and Charles N. Mann, General Technical Report PNW-79. Copies are available from the Pacific Northwest Station.

Primer describes solar radiation

Foresters who have an understanding of the basic principles governing the flow of energy between the sun and the earth can use this information to their advantage in managing forests. This is the basic premise of a new publication from the Pacific Southwest Station, titled *Solar Radiation as a Forest Management Tool: a Primer of Principles and Application*, General Technical Report PSW-33-FR20. Authors Howard G. Halverson of the Northeastern Station and James L. Smith of the Pacific Southwest Station designed the primer for foresters and other wildland managers who have not had any formal training in micrometeorology. The authors begin with an overview of what they call "earth-sun relations." In this, they lay the foundation for their discussion of the ways in which these relations affect tree shadow length—one of the most important tools a forest manager has for manipulating the amount of sunlight and heat that reaches the forest floor.

"Foresters can control solar radiation with tree shadows—or the lack of shadows—for many purposes," they explain. "For example, soil moisture can be controlled, to some degree. Stream temperatures can be ameliorated to make conditions more favorable for certain species of fish. Snow-covered campgrounds or roads can be opened up earlier in the year than usual. Many other goals can be achieved by using the sun's energy, both as direct radiation and as absorbed and reradiated heat."

The new primer complements and amplifies some of the ideas presented in the 1974 Smith and Halverson publication, *Controlling Solar Light and Heat in a Forest by Managing Shadow Sources,* Research Paper PSW-102-FR20. This earlier report, which is still available, describes a computerized method for calculating the length of tree shadows in forests of various slopes and aspects. Separate sets of tables, in which shadow lengths have already been calculated for Western U.S. forests of from 36 through 50 degrees north latitude, are available as supplements to the report.

For copies of these reports, write to the Pacific Southwest Station, Berkeley.

Model predicts lightning-fire ignition

If lightning is lighting up your life you might be interested in *A Model for Predicting Lightning-Fire Ignition in Wildland Fuels,* by Donald M. Fuquay, Robert G. Baughman, and Don J. Latham. In this publication, Research Paper INT-217-FR20, the authors describe a model for predicting the number of lightning-fire ignitions in wildland fuels. Through the use of a lightning activity level (LAL) guide the user can correlate cloud and storm development with the expected amount of cloud-to-ground lightning. The lightning-fire ignition model estimates the maximum number of ignitions to be expected under specific conditions. The authors state that the probability of these ignitions becoming reported fires is not covered in this model, but is the subject of future work.

The Intermountain Station has copies of this research paper.

New equipment monitors aerial spraying

Equipment which monitors and records data on pesticide application from spray aircraft has been developed at the Pacific Northwest Station. It records spray pressure, flow rate, total flow, elapsed spray time, total spray passes, relative humidity, and air or liquid temperature. The length of each spray swath can also be calculated. The equipment is designed for use on both rotary and fixed-wing aircraft which use internal, external, or underslung spray systems. These can be either boom-and-nozzle or spinning type atomizer systems. The unit consists of two metal boxes containing electronics, digital counters, and a strip-chart recorder connected by cables to sensors attached to the spray equipment. It is light weight, and power requirements are minimal. The electronics are shielded from the effects of electromagnetic interference.

Equipment Specialist Richard Orchard designed the instruments to gather data on pesticide spraying for research purposes. But the same type of data should be useful in pilot and control programs. In the past, aircraft pilots have been expected to make visual observations about spray pressure and the functioning of spray nozzles in addition to flying the aircraft safely over a marked course at a given speed and height while turning the spray on and off at designated places. There has been no record of equipment operation to determine whether the spray equipment functioned as planned.

Field and laboratory testing of a prototype began in 1976. The equipment is described by Orchard in "Onboard equipment for monitoring aerial spray application parameters," which appeared in *Agricultural Aviation* for January 1979. Reprints are available from the Pacific Northwest Station. Inquiries about borrowing prototype equipment should be directed to C. G. Thompson, Forestry Sciences Laboratory, 3200 Jefferson Way, Corvallis, Oregon 97331.

Wood - a viable energy source?

A recent Rocky Mountain Station report explores the use of wood as a potential energy source in the central and southern Rocky Mountain Region. Considerations in the study involve the economics of using wood as fuel, the energy potential of timber and mill residues, and large and small scale proposals for wood energy.

Proposals for wood energy use include; a chemical recovery plant, a wood gasification plant, a plant for direct firing of wood residue, a pyrolysis process, and a proposal to use wood residues as an energy source for drying alfalfa and potatoe wastes.

According to the study, wood has several significant advantages over coal. It is a sulfur-free fuel that can be burned without costly antipollution devices. Wood fuel systems have less total emissions per unit of energy output than comparable coal systems, and, unlike coal, wood is a renewable energy source.

The study points out that wood must pass two tests to prove an economical choice. First, wood must be a cheaper source of energy than competing fuels. Second, use of wood as a fuel must be more profitable than use of wood for other purposes. Currently, these criteria are not met. However, with the rising costs of other fuels, and research on more efficient wood harvesting, wood may become an important energy source in selective situations, such as for the wood industries themselves.

Copies of the report, written by George R. Sampson from the Rocky Mountain Station, are available on request. Ask for *Energy Potential from Central and Southern Rocky Mountain Timber,* Research Note RM-368-FR20.

Measuring snow water content in restricted areas

Regulations governing the use of Wilderness Areas may pose a problem to people who need to continuously monitor snowpack depth and density in order to calculate snow water content and to predict water yield. The sophisticated equipment usually installed to measure snowpacks is frequently not permitted in Wilderness Areas. And, most travel with vehicles is prohibited—a disadvantage to those who need to regularly measure an array of sites in order to make reliable estimates.

Researchers James L. Smith of the Pacific Southwest Station and Howard G. Halverson, formerly of the Pacific Southwest unit and now with the Northeastern Station, have developed a new technique that may solve this problem. Their approach is to measure snow albedo (or reflectivity) using sensors carried in an airplane or helicopter. They have developed an equation that can be used to convert these albedo measurements into estimates of snowpack density. Snowpack depth can be estimated by checking aerial photos of marker trees. Once both depth and density are known, water content of the snowpack can be estimated.

Smith and Halverson have worked with data from five snow seasons in developing this technique. They found that, for at least 74 percent of the time, albedo measurements were as accurate as those obtained from a conventional gravimetric sampler. The work so far has been based on "ground data"; a major southern California supplier of hydroelectric power will make the first aerial tests of the technique this year, using sensors carried in a helicopter.

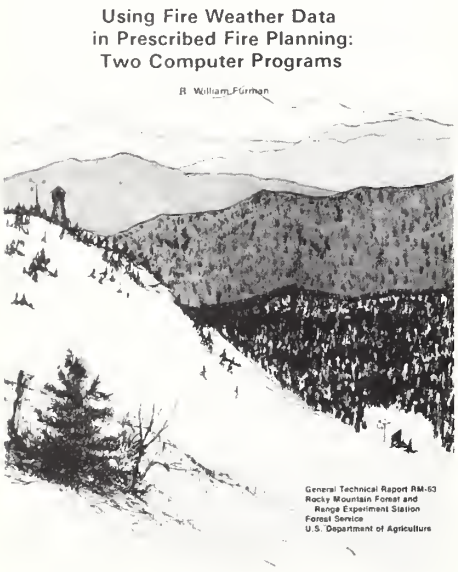
The technique is described in a recently issued report, *Estimating Snowpack Density from Albedo Measurement,* Research Paper PSW-136-FR20. The Pacific Southwest Station can provide copies.

Montana forest vegetation classified

In *Forest Regions of Montana,* Research Paper INT-218-FR20, Researcher Stephen F. Arno describes Montana's forests by geographic subdivision. Arno says there are two primary reasons for delineating the forest regions of Montana. First, the regions serve as a geographic reference for describing patterns of forest vegetation across the State. Second, delineating the regions contributes to regional classifications that are being developed from a national perspective. Arno feels that his forest region classification may be useful as a biologically-based stratification for forest research and forest management studies.

Copies of this report are available from the Intermountain Station.

Computerized prescribed fire planning



How many days of the year can local fire managers plan safe, prescribed burns? What time of the year are such days likely to occur? Do "safe" burn days fall consecutively, or, are they spread throughout the year?

How to determine answers to these and related questions is given in a report by Rocky Mountain Station Scientist R. William Furman.

According to Furman, Forest Service historical weather records reveal patterns which can be used by fire planners to predict how many burn days are likely each season. This is done by examining all past weather occurrences for an area and assuming that similar phenomena will occur with the same frequency in the future.

Furman has developed two computer programs to aid in fire planning. One, titled PRESCRB, synthesizes weather data into a meaningful form for fire use planning. The second, MERG3, obtains smoke dispersion data for use with the PRESCRB program. Both programs directly assess and use data contained in the computerized fire weather library.

Because fire planners' objectives and needs vary, Furman has incorporated a "prescription" function into the programs. This function enables users to include individual variables affecting their land area as well as a preference of burning methods.

The report, *Using Fire Weather Data in Prescribed Fire Planning — Two Computer Programs,* General Technical Report RM-63-FR20, is available upon request from the Rocky Mountain Station.

Photo series - a field tool

Forest managers often need information to help determine the fire hazard associated with thinning slash, and whether treatment of the slash is needed.

This information is available in *Photo Series for Appraising Precommercial Thinning Slash in North Idaho,* General Technical Report INT-46-FR20. The publication is the result of a cooperative effort between the State of Idaho, Department of Lands, and the Intermountain Station.

The series is an excellent example of how research can be applied to a specific land management problem. A land manager faced with evaluating the fire potential of thinning slash can use the photos to select the amount and type of treatment, the priority for treatment among several areas, and the amount of protection needed until the hazard has been reduced.

Authors are Wayne H. Koski, formerly with Idaho's Department of Lands, and William C. Fischer, research forester at the Intermountain Station.

Copies are available from the Intermountain Station.

☆U.S. GOVERNMENT PRINTING OFFICE: 1979—681-573/100

Monitoring nursery irrigation

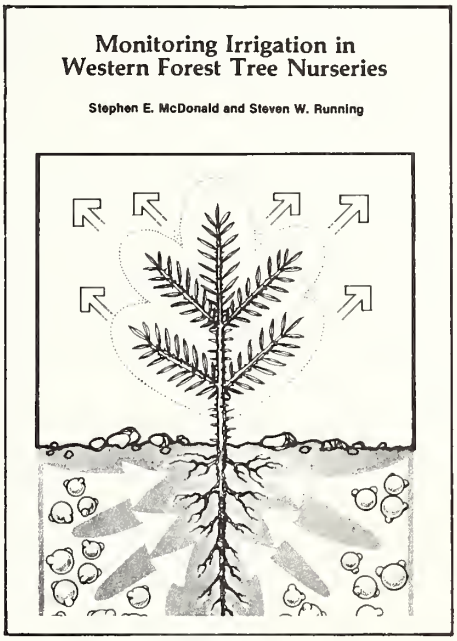
Rocky Mountain Station, in cooperation with the Forest Service's Rocky Mountain Region, has published a new report of benefit to nurserymen. The report reviews instruments available for soil and seedling water measurements, and makes recommendations for improving irrigation monitoring techniques.

Proper irrigation is a critical factor in avoiding the adverse effects of water stress on physiological and biochemical plant functions.

According to the report, most managers of bare-root and containerized nurseries primarily use visual/touch observation to monitor soil dryness. However, the authors feel additional, more precise methods are available and should be used.

For bare-root nurseries, soil moisture can be measured directly with soil tensiometers. Container nurseries can use the weighing method while seedlings are young.

In all nurseries, the authors recommend use of the "pressure bomb" because it is the only instrument that directly measures water stress of the seedling itself.



Other irrigation monitors discussed are: electrical resistance blocks, gravimetrics, "time schedule/water budget", thermocouple psychrometer, and neutron probes.

Further information can be obtained by writing for a copy of the report, *Monitoring Irrigation in Western Forest Tree Nurseries,* General Technical Report RM-61-FR20, by Stephen E. McDonald and Steven W. Running.

You won't want to miss the January issue. We'll cover mine spoil reclamation in the Southwest; classifying western Montana's grass and shrublands; current forest management in Hawaii and Micronesia; and look at a new way to predict the effects of forest management activities on wildlife habitat. We'll also review some new research publications available to you.

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